2004 DOE Hydrogen, Fuel Cell and Infrastructure Technologies Program Review

Low-Cost, High-Pressure Hydrogen Generator

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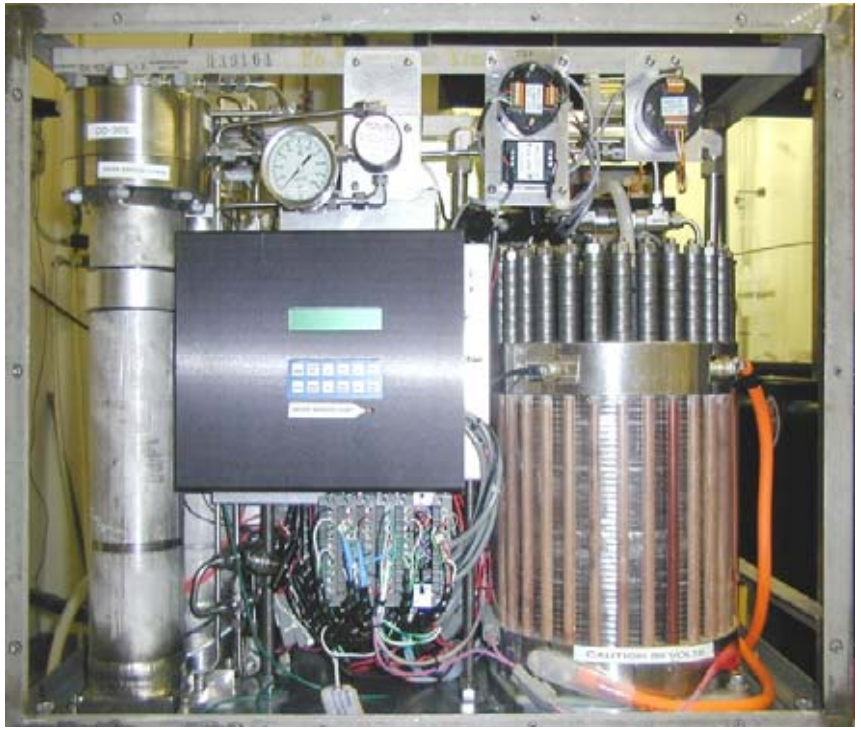
This presentation does not contain any proprietary or confidential information

Project Objectives

Overall Project

- Develop and demonstrate a low-cost, high-pressure water electrolyzer system
  - Eliminate need for mechanical hydrogen compressor
  - Increase electrolyzer hydrogen discharge pressure to 5,000 psig
  - Reduce capital costs to meet DOE targets
  - Demonstrate a 3,300 scfd high-pressure electrolyzer operating on a renewable energy source
  - Public outreach and education



Project Objectives

Past Year (Jan 03- Mar 04)

- Develop lower cost materials and fabrication processes for stack components
- Develop, fabricate and demonstrate an electrolyzer stack and system producing hydrogen at 2,000 psig
- Design, fabricate and test a prototype electrolyzer system that delivers hydrogen at 2,000 psig
- Design and fabricate a test stand for 5,000 psig operation

Budget

- Total Project Budget: $3.026M
  - DOE Share: $1.499M
  - Cost Share: $1.527M
- FY04 Funding
  - DOE: $245K
  - Contract awarded April 04
- Cost Share Funding to Date: $819K
  - Jan 03- Mar 04

Technical Barriers

DOE Technical Barriers for Hydrogen Generation by Water Electrolysis

- Q. Cost- capital cost, O&M
- R. System Efficiency- replace mechanical compressor with electrochemical compression
- S. Grid Electricity Emissions
- T. Renewable Integration
- U. Electricity Costs

DOE Technical Targets for Water Electrolysis for 2010 (for 250 kg/day system)

	Energy Efficiency (%LHV)	Cost $/kg
Cell Stack	81	0.25
Balance of Plant	98	0.07
Compression	95	0.16

Approach

- Incrementally increase the operating pressure of the GES differential pressure electrolyzer, through improved seal and endplate design
  - 1,000 psid in 2002; 2,000 psid in 2003
  - Planned further increases to 3,500 and 5000 psid
- Replace high-cost metal components with lower-cost materials
- System innovations to replace high-cost, high maintenance components

Project Safety

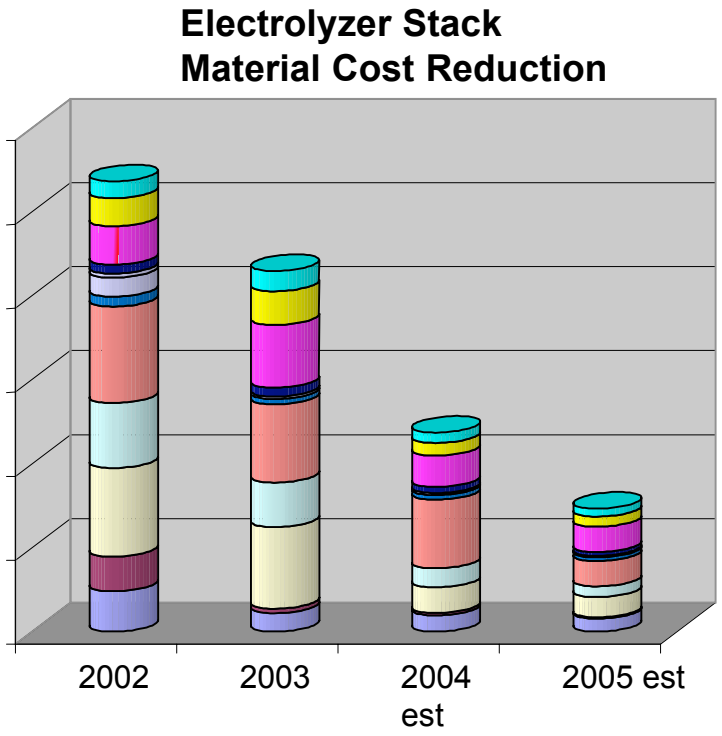
- GES has initiated a failure mode and effects analysis (FMEA) for our laboratory operations and prototype electrolyzer systems
- GES is developing a management of change (MOC) process for the project
  - Changes in stack and system components, control systems or algorithms, and operating procedures must be approved by project safety committee

Project Timeline

Task	2003				2004				2005			
	1	2	3	4	1	2	3	4	1	2	3	4
TASK 1. Stack Cost Reduction												
DEMONSTRATED LOW -COST CATHODE SUPPORT		X										
REDUCED STACK PARTS COUNT		X										
TASK 2. BOP Cost Reduction												
TASK 3. High Pressure Stack D esign												
TASK 4 2,000 psi Prototype												
COMPLETED STACK&SYSTEM			X									
Extended testing of Prototype System												
TASK 5. 5,000 psi Test Stand												
COMPLETED STAND FABRICATION			X									
TASK 6. 3,500 psi Short Stack												
Stack Complete									Δ			
TASK 7. High Pressure System												
System Complete											Δ	
TASK 8. 5,000 psi Short Stack												
Stack Complete											Δ	
TASK 7. Public Outreach/Education												

Technical Accomplishments

- Stack Cost Reduction
  - Developed and demonstrated a low-cost cathode support
  - Reduced electrolyzer stack parts count by >50%
  - 30% reduction in stack materials cost, 40% reduction in fabrication labor
  - Demonstrated operation of lab-scale hardware at 10,000 Amps/ft^2

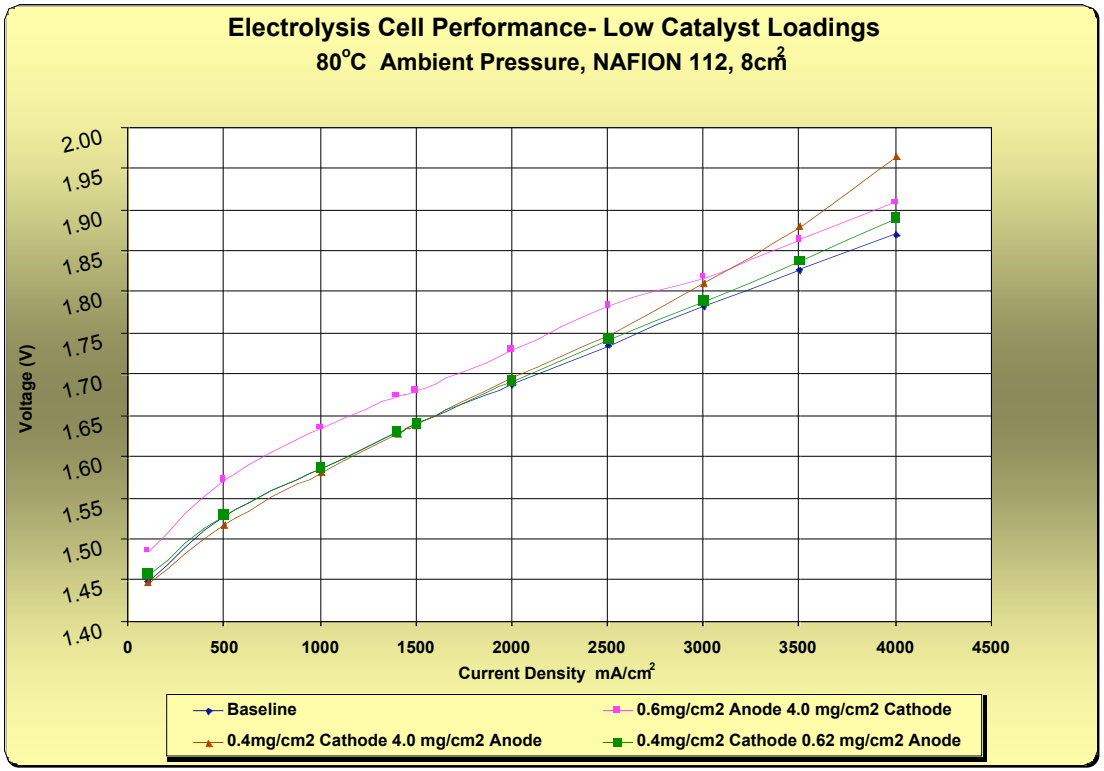


Technical Accomplishments

- Increased Operating Pressure
  - Developed and demonstrated operation of 140 scfd stack at 2000 psid
  - Developed, fabricated and demonstrated a system for production of 140 scfd hydrogen at 2000 psid

Technical Accomplishments

- Improved stack efficiency
  - Reduced cell voltage by 10% while decreasing MEA cost
  - Single-cell durability
    - Demonstrated > 1,000 hours



Interactions and Collaborations

- Collaboration with General Motors to develop low-cost electrolyzers for the hydrogen economy
- Center for Technology Commercialization in Westborough, MA will provide public education and outreach
  - K-12 teacher education
  - demonstrations and literature distribution at energy and transportation fairs and related venues

Future Plans

- Remainder of FY 2004
  - Develop and implement FMEA and MOC programs
  - Develop a low-cost anode support structure
    - Demonstrate and test in short-stacks
  - Durability testing of low-cost cathode support
    - Cycle in automated test-stand at 1,000 psid
    - Demonstrate for minimum of 10,000 cycles over 2,000 hours
  - Improvements to 2,000 psid system
    - Extended testing for approximately 500 hours

Future Plans

- FY 2005
  - Cost Reduction
    - Continue reduction in stack parts count
    - Reduce stack costs by additional 35-50%
  - Stack and System Development
    - Develop and demonstrate 3,500 psid electrolyzer stack and system
    - Design, fabricate and demonstrate 5,000 psid short-stack